

# Deep Underground Science and Engineering Laboratory (DUSEL)

*Workshop*

Biological/Geosciences/Engineering Components

*Comments by*

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# Industrial Use of Underground Space

*See Proc. Intern'l Symp. ROCKSTORE 77; '80 (Stockholm)*

## Shallow

Surface Space Conservation (e.g. transit, storage);  
Environmental Protection (air) Underground Nuclear Plants;  
Industrial Facilities; Attenuation of Surface Effects  
(earthquakes; noise; temperature variation); Civil Defense  
(air attack; weather.); etc.

## Deep

Mines; Nuclear and Hazardous Waste Isolation; Petroleum  
Extraction; Tunnels; Transit; Water Supply; CO<sub>2</sub>  
Sequestration; Geothermal Energy; Defense Facilities.



# NSF Solicitations

*(M.S. Turner 03/29/04)*

**Solicitation 1:** Planning grant (s) to define science and infrastructure requirements for science modules

**Solicitation 2:** Site development grants

**Solicitation 3:** Planning grant to develop full proposal including suite of initial experiments

## Solicitation 1: Planning grant(s) to define science and infrastructure requirements for science modules

### *Requirements*

- Define science and engineering research.
- Clearly articulate the program (initial suite of experiments, future program) and associated underground infrastructure requirements.
- Describe any associated requirements for instrumentation R&D.
- International context (partnering, duplication, etc.).



# EarthLab Topics

([http://www.geo-prose.com/projects/pdfs/earthlab\\_6.18.03.pdf](http://www.geo-prose.com/projects/pdfs/earthlab_6.18.03.pdf) )

## Scientific Themes:

- Microbial Life at Depth
- Hydrologic Cycle
- Rock Deformation and Fluid Flow
- Rock-Water Chemistry
- Deep Seismic Observatory
- Geophysical Imaging

## Integrated EarthLab Activities:

- Characterizing the EarthLab Site
- Ultradeep Life and Biogeochemistry Observatory
- Deep Flow and Paleoclimate Laboratory and Observatory
- Induced Fracture and Deformation Processes Laboratory
- Deep Coupled Processes Laboratory

# EarthLab Topics

## Integrated EarthLab Activities (continued):

- Scientific and Engineering Innovation
  - *Genetic materials, novel microorganisms, and biotechnology applications*
  - *Analytical techniques for geomicrobiology and exobiology*
  - *Environmental remediation*
  - *Subsurface imaging*
  - *Drilling and excavation technology*
  - *Natural resource recovery*
- Education and Outreach



# Working Groups

1. Solar Neutrinos
2. Double Beta
3. Long baseline experiments
4. Nucleon Decay/atmospheric neutrinos
5. Dark Matter
6. Hydrology and coupled processes
7. Geochemistry: water-rock interactions
8. Rock mechanics and seismology engineering

## Working Groups

9. Applications: homeland security, storage (waste disposal, oil, carbon sequestration)
10. Bio-geology methodology; (Determining sampling objectives & sites, sampling strategies, contamination control, enhanced methodologies for biomarker analysis)
11. Micro and molecular biology (Microbial diversity, physiology, activity and molecular evolution)
12. Low background counting facilities and prototyping (pre-DUSEL and at DUSEL)
13. Education and Outreach



## Bio/Geo/Engineering Working Groups and Coordinators

6. Hydrology and coupled processes  
*Brian McPherson, Eric Sonnenthal*
7. Geochemistry: water-rock interactions  
*Steve Kesler, Mike Hochella*
8. Rock mechanics / seismology / engineering  
*Larry Costin, Paul Young*
9. Applications: homeland security, storage (waste disposal, oil, carbon sequestration)  
*Francois Heuzé, Jean Claude Roegiers*
10. Bio-geology methodology; (Determining sampling objectives & sites, sampling strategies, contamination control, enhanced methodologies for biomarker analysis)  
*Tommy Phelps, Tom Kieft*
11. Micro and molecular biology (Microbial diversity, physiology, activity and molecular evolution)  
*Jim Fredrickson, TBD*

## 'Issues'

- Site-Independent Scientific Themes
- Scientific Modules (common infrastructure)
- Incompatibilities
- Desirable Site Features (e.g. depth; location; dimensions; 3D development; access (hoist/drive-in))
- International Facilities & Programs [operating mines; URL's (waste isolation); IAEA Centres]
- Merits of Dedicated (Engineering) Science Facility (uniqueness; complementarity)



## DAFSAM: Drilling Active Faults in South Africa Mines

([http://earth.es.huji.ac.il/reches/DAFSAM/white\\_paper\\_DAFSAM.pdf](http://earth.es.huji.ac.il/reches/DAFSAM/white_paper_DAFSAM.pdf))

Thomas Jordan, Earth Sciences, USC, Los Angeles, CA, USA

The DAFSAM project is centered on drilling funds from the ICDP (International Continental Scientific Drilling Program)... As the mines allow access to fault-zones down to 4 km depth, the drilling from the tunnels is relatively inexpensive. Moreover, it will be possible to carry out an unprecedented suite of geological and seismological studies, as well as to directly measure both stress and strain in the vicinity of active faults at significant depth. The research operations will be funded by additional resources. First,

*the project utilizes the billions of dollars of infrastructure in the deep South African mines...*

The scientific objectives of the project are

*the characterization of near-field behavior of active faults before, during and after earthquakes.*

## DAFSAM: Drilling Active Faults in South Africa Mines (*continuation*)

We intend to measure the ambient and time variation of the stress field (orientation, magnitude, heterogeneity) at the fault proximity, to characterize the fault zone structure (fault rocks and geometric complexity) and the fault zone seismic signature (guided waves and shear-wave splitting). We will determine the rupture energy balance (temperature and microstructure measurements), assess the nonlinear rheology (damage and healing) and determine rupture parameters (e.g.,  $D_c$  and rupture velocity). The DAFSAM project includes several

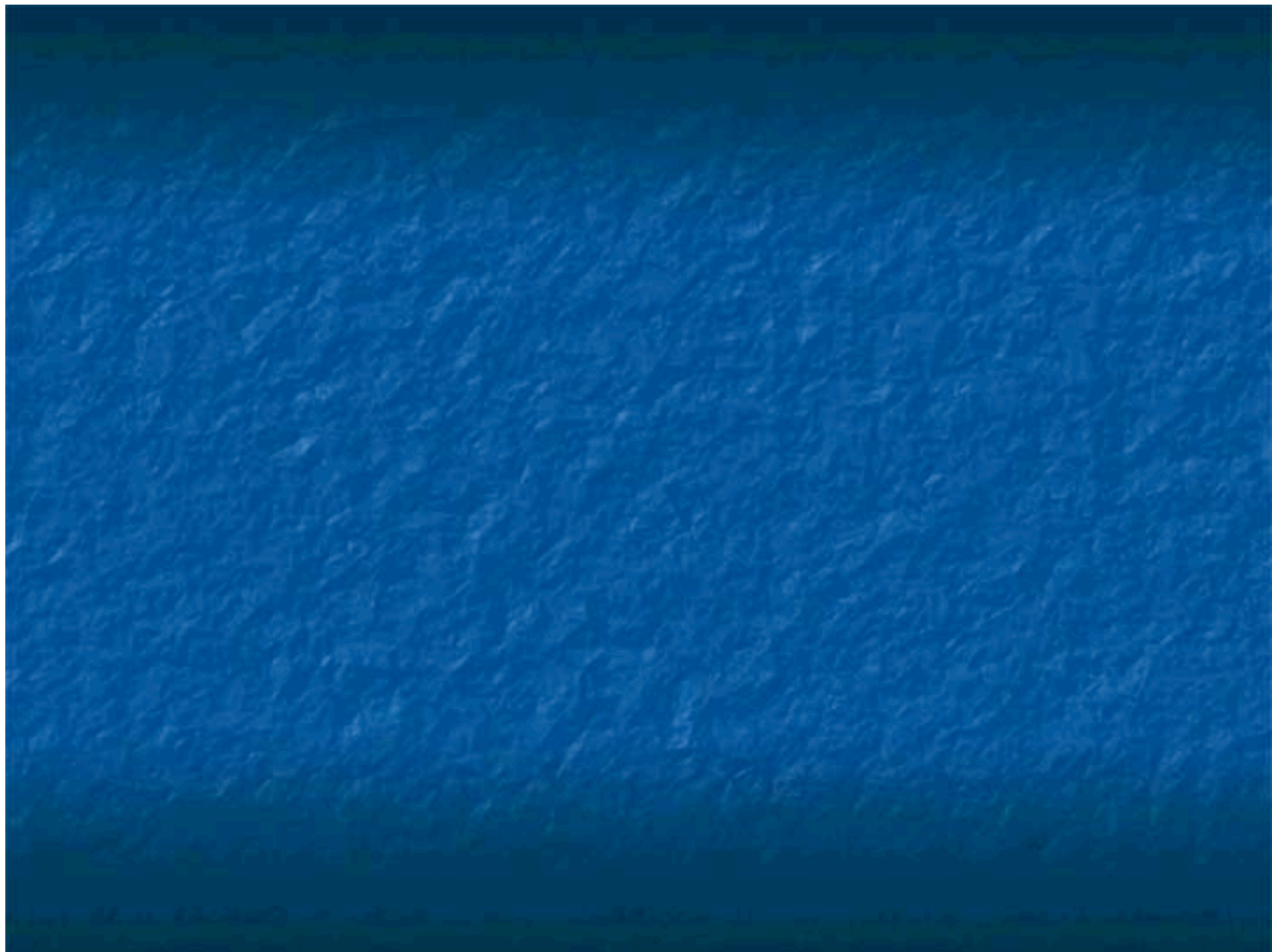
*complementary studies of the analyses of time-dependent geochemical composition of the fault-rocks as well as the possible interaction between fault slip and microbiological activity.*

Active Mine; - Changing Stress Environment

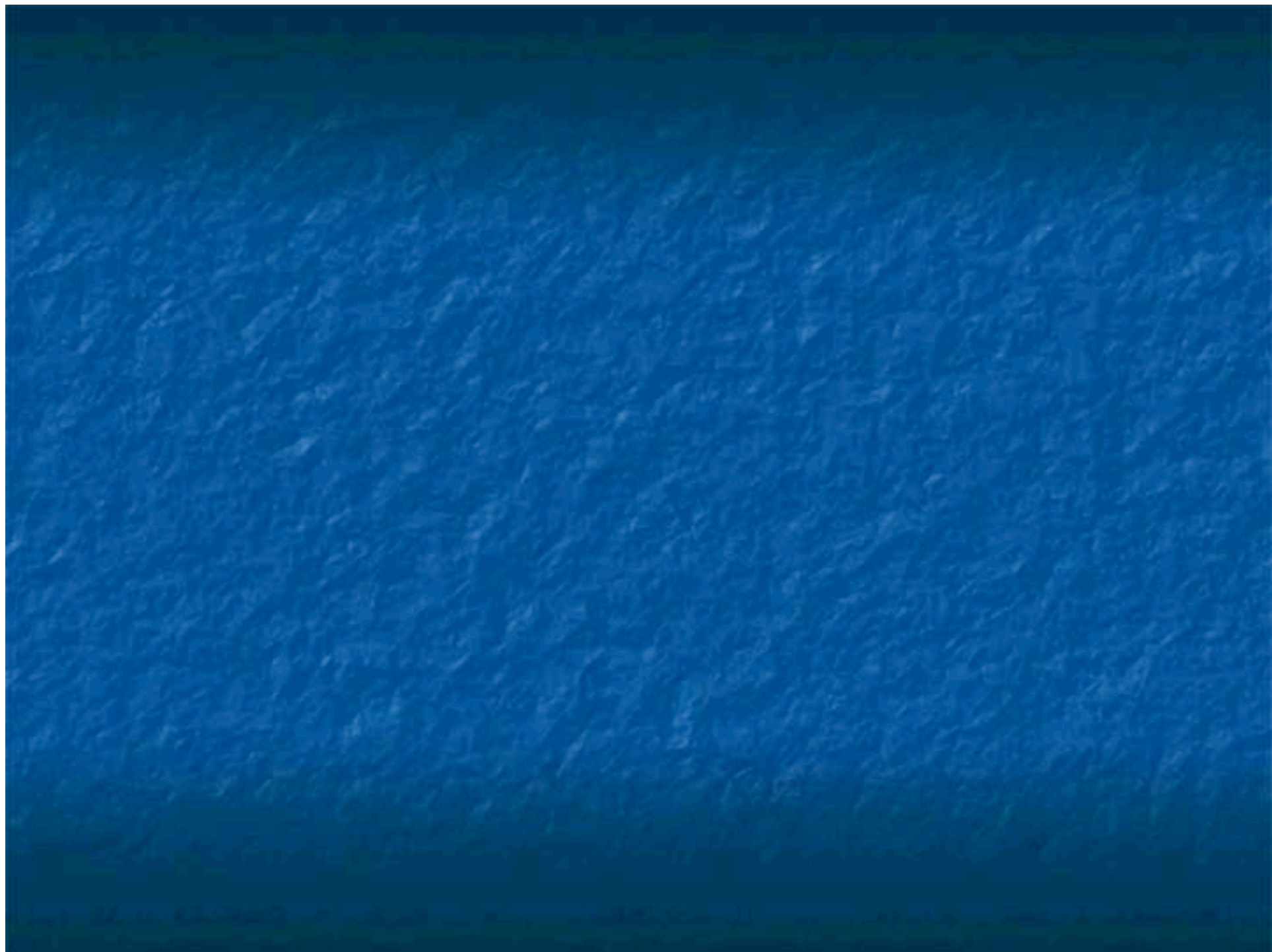


## DAFSAM – Principal Contributors

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# ***Conclusions***

## Geosciences/Engineering (Bio-Chem-Hydro-Thermal-Mech..Physics)

"We must hang together or we will surely all hang separately."

- *Major **interdisciplinary** opportunities defined by Workshop.*
- *Working Group Coordinators will add more (please submit ideas)  
([fairh001@umn.edu](mailto:fairh001@umn.edu))*
- *Biological opportunities primary.*
- *Some study opportunities site dependent-others less so.*
- *Maximum benefit if discussion of science requirements at start of  
site characterization (esp. for biological).*
- *Examine potential for interaction with/ extension to other sites.  
(US and international) and industry collaboration/application.*
- *Build on EarthLab recommendations.*



## Conclusions (cont'd)

- *Imaging*

*Underground verification of surface and cross-hole interpretation.  
3D imaging of rock block (1m~100m).*

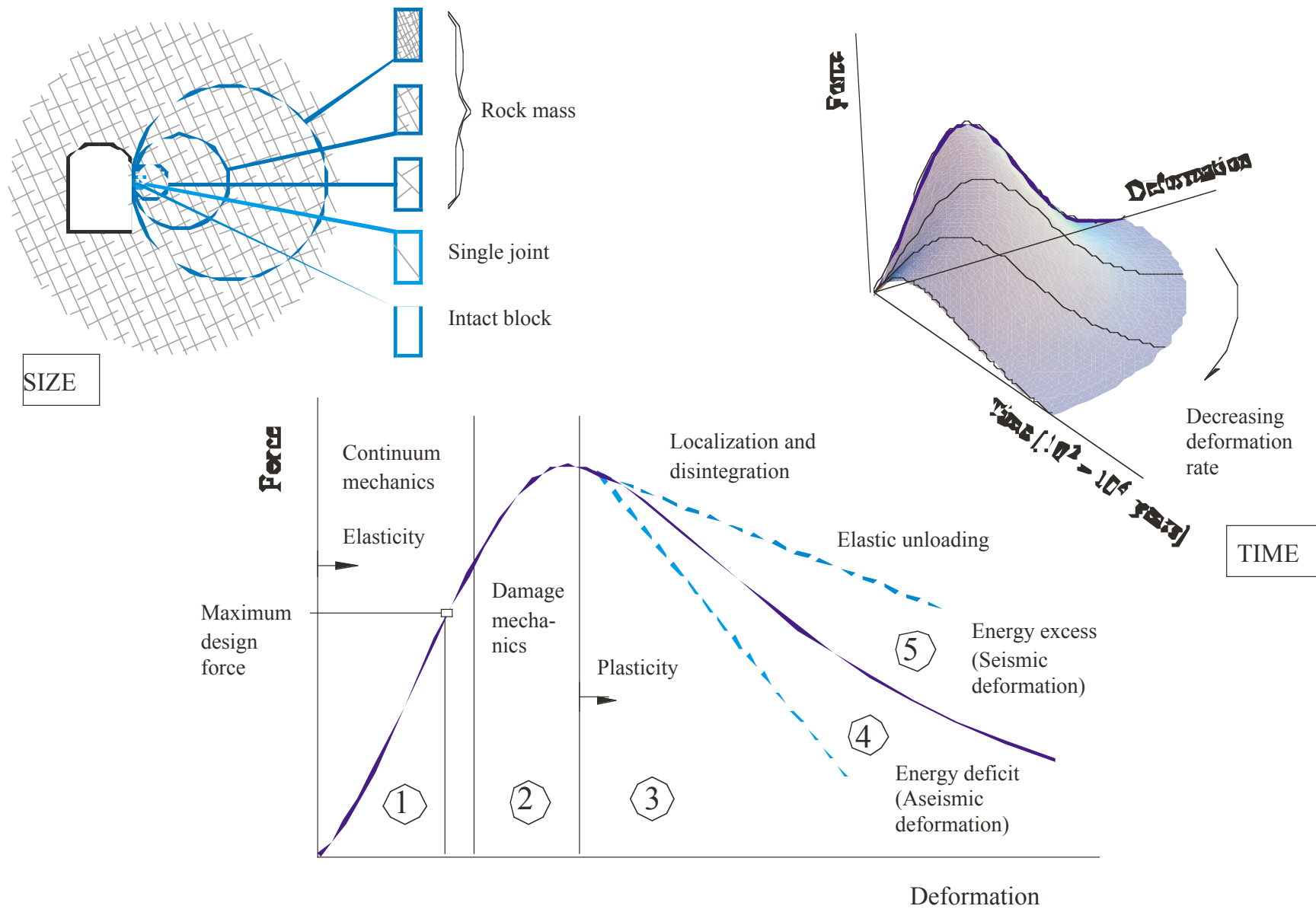
*Numerical Modeling and Graphics capabilities well developed  
Need physical data on in situ behavior.*

- *Underground correlation to Earthscope*

*Long base line instrumentation of tunnels/raises (tiltmeters;  
Origin of, volumetric variability of stresses (tectonic strain rate/rheology)*

- *Characterization of rock mass.*

# Scale Effects in Geo-Mechanics – Space and Time



Complete Load-Deformation Behavior